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Development of electrical generator using ferromagnetic powders and non-magnetic fluid

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Abstract. This paper reports a broadband vibration resonance model for vibration energy harvesting using ferromagnetic powders and suggested a non-resonance type device model by adding a non-magnetic fluid(water) to this device model to support frequencies lower than 10 Hz. The work builds on a vibration energy harvesting device reported at Mechanical Engineering Journal [1].In this study, because the electric generator can convert the reciprocating motion into electrical energy without rotary motion by ferromagnetic powders and non-magnetic fluid for the naturally occurring kinetic energy that is small such as the creature exercise, it may be said that this electricity generator is effective. We suggest that using ferromagnetic powders for broadband vibration and non-magnetic fluid for the low-frequency vibrations as devised in this study could be a breakthrough in solving the technical problems that arise in vibration energy harvesting.

1.Concept

It is difficult to generate energy from small, low-frequency (0.1–10 Hz) vibrations such as those produced by animals or natural phenomena by using the electromagnetic induction method. So far, authors have performed some basic study on the development of such a generation system [2, 3]. This generation system converts vibrational energy into electric energy using a permanent magnet and a pipe, which encloses ferromagnetic powders and non-magnetic fluid (water) (Fig. 1). The ferromagnetic powders form spike-shaped aggregates under the influence of the permanent magnet's magnetic field. When the pipe is vibrated by an external movement, the motion of these aggregates creates electromotive force because of the magnetic field crossing the coil by the right-hand rule.

This is a maintenance-free, durable, highly inexpensive generation system without moving parts. In this study, we have developed a generation system that is durable, inexpensive, and nearly maintenance-free due to removed mechanical parts such as sliding. In this system, a permanent magnet is placed outside a pipe filled with ferromagnetic powders and liquid, and electricity is produced by electromagnetic induction as a result of vibration of the system. The objective of this study is to examine the values of vibrational frequency and the magnetic substance to use and their relations with the efficiency of generation. An example of specifications is as follows. The vibration-driven generator was fixed to a shaker for the test tube to make it vibrate at 5.6 Hz (respective vibrational

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acceleration:2.728 G) with an amplitude of 40 mm. The electrical generator generated electricity in 185mVp-p, 2mA.The generation electricity per volume is 2.16[$\boldsymbol{\mu W/cm^3}$]. Furthermore, we are developing an efficient smaller electrical generator.

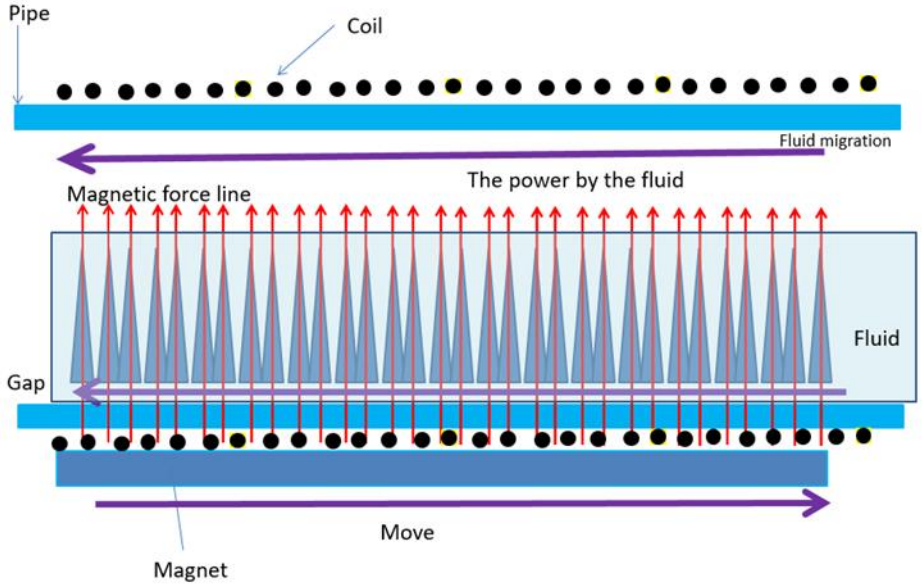

Fig. 1 Conceptual diagram of the developed system. Ferromagnetic powders and liquid are enclosed in a pipe. The ferromagnetic powders become a spikes-formed lump by the magnetic field of an outside permanent magnet.

2. Characteristic of the electrical generator

· We made many flexibility system vibration system by using ferromagnetic powders, and broadband of the vibration generation s, and broadband of the vibration generation enabled.
· The structure of the electrical generator is simple. Thus the electrical generator is adjustable and is adaptable itself for environment.
· We enabled low frequency vibration generation by using a nonmagnetic fluid.

Previously, we performed electromagnetic analysis using computer simulations because we conceived that the behavior of the fluid, direction of magnetic induction, and magnetic flux substantially contributed to our generator's electricity output. We were able to increase generation efficiency by analyzing the magnetic flux distribution of the generator's permanent magnet [1].Ferromagnetic powders used in this study are made of iron and iron compounds naturally available in our living environment. For example, ferromagnetic powders are included in magnetic tapes and groundwater and can harvest infinite, inexpensive energy out of industrial waste. It can be stated that this study "is the correct fusion of green energy and ecology."

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